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BICYCLES AND TRICYCLES.

Bicycles and Tricycles. An Elementary Treatise on their Design and Construction. With Examples and Tables. By Archibald Sharp, B.Sc., Whitworth Scholar, Associate Member of the Institution of Civil Engineers, Mitglied des vereines Deutscher ingenieure, Instructor in Engineering Design at the Central Technical College, South Kensington. With numerous Illustrations. Octavo. Pp. xviii + 536. 565 Figures. Index. (London, New York, and Bombay: Longmans, Green, and Co., 1896.)

IT is difficult to know who to congratulate most, the author of this really valuable work or the public, especially the cycle manufacturing branch of it, for whose edification and improvement it has been written.

The second paragraph of the author's preface so aptly summarises the need for such a book that, in spite of its length, it is worth quoting in full.

"The present type of rear-driving bicycle is the outcome of about ten years' practical experience. The old 'Ordinary,' with the large front driving-wheel, straight fork, and curved backbone, was a model of simplicity of construction, but with the introduction of a smaller driving-wheel, driven by gearing from the pedals, and the consequent greater complexity of the frame, there was more scope for variation of form of the machine. Accordingly, till a few years ago, a great variety of bicycles were on the market, many of them utterly wanting in scientific design. Out of these, the present day rear-driving bicycle, with diamond frame, extended wheel base, and long socket-steering head—the fittest—has survived. A better technical education on the part of bicycle manufacturers and their customers might have saved them a great amount of trouble and expense. Two or three years ago, when there seemed a chance of the dwarf front-driving bicycle coming into popular favour, the same variety in design of frame was to be seen; and even now with tandem bicycles there are many frames on the market which evince on the part of their designers utter ignorance of mechanical science. If the present work is the means of influencing makers, or purchasers, to such an extent as to make the manufacture and sale of such mechanical monstrosities in the future more difficult than it has been in the past, the author will regard his labours as having been entirely successful."

It is merely necessary for any one to go to one of the annual cycle shows and to overhear the, no doubt, honestly attempted explanation of the advantages of some hopeless device, and the apparent satisfaction with which some of these plausible follies are devoured by a section of the public, to feel that Mr. Sharp has expressed himself with too much enthusiasm. Perpetual motion is no more dead now than it ever was; in fact, in consequence of the extraordinary successes in the cycle business during the past year or so, vendors of schemes for creating power are doing a better business than ever. If fifty books as excellent as the one under review were in their hands, these people would always rise superior to the absurd limitations which mere conventional mechanicians recognise.

The real value of Mr. Sharp's book will, in the main, be felt by the manufacturers, who, in many cases, possessed of mechanical instinct, but without sound technical training, are honestly attempting to improve their produce. If any of them is able to handle elementary algebra and geometry, which is all that is asked of the reader, he will be taken in the first portion of the book through a course of instruction in which the principles, so far as they are required for cycle design, of kinematics, statics, dynamics, friction, and the stresses and strains in simple and compound structures are explained in a manner which is admirable. If he is not able to make use of the very elementary mathematical processes employed, he may yet follow much of the reasoning.

The first of the three parts into which the book is divided, is in reality itself an excellent text-book which has the unusual merit that it is not written for students or to meet a syllabus, but simply with the object of enabling any ordinary person with the usual school education to obtain a clear insight into the principles of construction and design. If there is one chapter in this part which will be valued more than others it is the one on bending, in which the theory is explained and then applied to the case of ordinary beams and tubes of various sections The numerical tables in which the sectional areas, weights per foot run, and moduli of bending resistances of solid bars and of steel tubes, should be of use to the designer.

The second part of the book, in which the well-known machines which have taken their part in the evolution of the modern cycle are described, while interesting in many ways, is of decidedly less utility than the first or last, or rather it would be so if it were not fortified by chapters on stability of cycles, steering of cycles, resistance of cycles, and gearing in general.

The third part, which is the largest, is simply one on details; but where there are such a host of details as there are in a bicycle, and each becomes the subject of an essay, the proportion assigned cannot be considered too large. For instance, seventy-two pages are devoted to the frame and to the stresses to which it is subjected Wheels, bearings, chain and other gearing, tyres, pedals, cranks, springs, saddles and brakes are all discussed at length.

Before examining this book more in detail, it may be worth while to say that Mr. Sharp is well known as an ingenious and sound mechanical engineer, so that readers of his book may be well assured that if they come across any statement which seems at variance with their ideas, or with what appears to be common sense, or even with the convictions of racing men, the statement is nevertheless one to be considered carefully.

The chief doubt which occurs to the writer of this review is whether the first 110 pages should have been written at all. This part is, after all, merely a text-book of mechanics, put together, it is true, in such a manner as to give prominence to the problems which a study of the cycle presents, but nevertheless a text-book abstract and black-boardy. If it is desirable that such a text-book should be incorporated in a work on bicycles and tricycles, then no fault is to be found with the substance of it, for it is clear, accurate, and to the point. At p. 110 the all-important question of the stiffness of tubes is reached. This is gone into at some length, both with circular and with other shaped tubes. Some attention has recently been given to the question of D-shaped tubes, which are being employed for the lower back fork of the rear-driven bicycle. The object of making these tubes of D-section is to obtain the necessary stiffness with a narrow tube, as horizontal space is valuable at this part. Doubt has been expressed by cyclists upon the safety of D tubes when thus used. They will be glad to hear from Mr. Sharp, or to calculate for themselves if they like, as he has shown them how, that the D-tube is stiffer than a round tube of equal width and weight by rather less than 1 per cent. Mr. Sharp, however, advocates the use of tubes of rectangular section for this part of the machine, for they are roughly 33 per cent. stiffer than elliptical tubes of the same depth, breadth and weight.

In the chapter on the strength of materials, a result is given which will surprise those who do not realise the importance of depth in a beam, but 'who only consider tensile strength and density. Steel is so enormously strong for its weight that, with the exception possibly of some of the new alloys, it is the one material on which the designer of strong and light structures depends. Now in the case of solid beams of the same length, breadth and weight, a light material, such as wood, may be made so enormously deeper than one of steel, that the stiffness which depends upon the cube of the depth actually exceeds that of steel. For this reason a wooden cycle rim is lighter than a solid steel rim of the same width and strength. It probably is not lighter than a hollow steel rim of the same outer shape and weight, any more than a solid wooden beam would be lighter than a compound beam made of steel of the same width, weight and strength in which nearly all the material is at the upper and lower surfaces.

The concluding chapter of Part i. deals with the strength of materials. In this there are two sections of special interest to cyclists. The first relates to the "helical tubing" of the Premier Company. This is an ingenious composite tube made by rolling band steel in a helix, so that at no point has it less than two thicknesses, and then brazing all together. By this method of construction a higher grade of steel can be employed than any used in drawn tubes, and a gain of about 50 per cent obtained in tenacity. This, of course, is at the expense of ductility, so that while a frame built of helical tube will be stiffer for its weight than one of solid drawn tubing, it will, or perhaps it is better to say it should, give way suddenly to accidental stresses which would merely bend an ordinary tube.

The other interesting point is the effect of repeated small stresses of an amount which applied even many hundred times would be quite incapable of damaging a material. Certain parts of a bicycle are subject to alternate stresses in ordinary use, while others are constantly pulled in the same direction. The latter may therefore be made with a somewhat lower factor of safety than the former.

Part ii. is partly historical. This will be welcomed by readers very differently, according to their individual cycling experience. Those who have ridden since the 'seventies, or have followed the progress of the cycle, more especially in the last fifteen years, may turn over these pages with a certain melancholy interest, while those who have only recently joined the ranks of cyclists will probably be tempted by curiosity to learn something about the machines which so recently they despised. In the writer's opinion, the first fifty pages of this part is not likely to seriously interest any one for whom the really new and valuable part of the book has been written.

With Chapter xvii. the valuable portion of Part ii. begins. This is upon the stability of cycles. The author explains the bicycle balance by supposing the rider to steer unconsciously in such a curve that the centrifugal force balances the tendency to overturn. All that can be said of this is that when the rider is following a curved path he must lean over to the angle which every one knows, for this is what may be called the dynamical vertical; but small variations from this have to be counteracted just as much as small variations from the real vertical when a straight path is to be followed. Mr. Sharp speaks of the lateral oscillations that are necessary for stability as being pendular, so that a high bicycle has a slower period than a low. This, no doubt, is true in a way, but the essential difference between a hanging and an inverted pendulum are not pointed out. The former has a natural period—that is, it takes the same time to reach the vertical from any moderate inclination; but the inverse is not the case, an inverted pendulum has no natural time to fall from the vertical to any definite inclination, but only from one inclination to another, and the comparison of the periods between high and low machines can only be made when these inclinations are the same for both. The main point is that there is no natural period for the inverted pendulum, the time becoming greater as the start is made from a truer vertical, and also greater as the angle of fall becomes greater. For this reason it would seem that the more correct view is that the bicycle balance consists in merely running the wheel so as to bring the line of contact with the ground vertically under the centre of gravity, the vertical being the dynamical vertical for the particular speed and average radius of path.

There is one section in this very interesting part which is at variance with the supposed experience and almost universal belief of riders. This is upon the effect of pedal pressure upon side slip. Page 215 rather unnecessarily traces the forces upon the frame and wheel in consequence of pressure upon one pedal. Obviously no sustained pressure by the rider upon the pedal can produce a lateral force upon the tyres, however much riders may think the contrary; but is it not possible that this lateral force may exist, and to a more than perceptible extent, in consequence of the fact that it need not be sustained, that it is not one of the entirely balanced internal forces, but is unbalanced, the lateral momentum of the rider's body supplying the force which is external to the frame? This depends for its possibility upon its not being sustained, for if it were the rider would move laterally off the machine; as it is he begins to acquire a lateral velocity, which is pulled up and reversed at the next half-turn. This is the lateral equivalent of the objectionable vertical swaying of the body, which enables the rider to exert an effort on the pedal greater at the time that it is useful than that which the vertical force due to his mere weight would allow. In the middle of the stroke the vertical acceleration of the body is made a maximum, and so the position is at its lowest. At this time, therefore, a greater pressure is available; at the ends of the stroke, where pressure is less useful, less is applied, and gravity is occupied in stopping the rise and starting a fall of the body. Thus the rider is able to store up the effect of gravity at the less useful, and employ it at the more useful periods, and so relieve his arms from the holding-down strain, which is so tiring.

After dealing with other points in connection with stability, the author comes on to steering in general, and to the difficult subject of steering and balancing upon the "Rover" type of safety without using the hands. Five pages of somewhat difficult reasoning are devoted to this point, and after the establishment of all the forces and couples which come into play, a theory is elaborated which should apply even to the case when the steering axis cuts the ground at the point of contact of the front wheel. It is often stated that riding without hands under these conditions is impossible; difficult it is certain to be, for this feat, as it used to be considered, is certainly easier when the castor action is moderately increased. It would be interesting if expert cyclists who have the means would see if they can succeed.

The writer noticed, when first practising to ride without hands, that the lateral hinging of the body about a joint in the neighbourhood of the saddle seemed to have a definite influence. This motion is evidently under the control of the rider, and so an actual variation of inclination can be forced upon the machine, the amount relatively to that in the upper part of the rider's body depending upon the moments of inertia of the two systems about their independent horizontal fore and aft axes. By this means it is certainly possible to make a rapid and temporary inclination of the frame, which, combined with the gyroscopic action of the front wheel, is all that is needed to control the steering. No doubt the forces calculated by Mr. Sharp act as he has explained, but to what extent they, or the temporary dynamical action just described, are those which are depended upon in practice, whether consciously or not, the writer is not prepared to say.

The chapter on resistance of cycles is very instructive. The conclusions are represented graphically, so that any one non-algebraically-minded can grasp the enormous importance of air resistance at high speeds. Extrapolating from these curves, it is seen that a man who can drive his machine under present conditions through the air at, say, 30 miles an hour, would, if road and machine resistance only had to be met, be able to drive at 330 miles an hour, or if he can actually go 20 miles an hour, he would be able to drive his machine 100 miles an hour. This shows the very essential part that pace-making plays in the cycle race. Whether Dr. Turner's theory on the fatigue caused by brain work in constantly determining the most suitable speed, plays any part or not, it is evident that a long machine with half a dozen riders upon it, or an autocar just in front of the racer, will make such a draught as materially to reduce the enormous resistance he would meet with if the air were still. The writer would like to propose a method to enable great speeds to be attained, which, however, is of spurious interest, since in real cycling the wind resistance must be overcome. All that is necessary is that a large box or small house with glass sides big enough to entirely surround the rider, but with a safe margin, should be dragged by steam or other power along at gradually increasing speeds until the rider shows that he is beginning to lag. Of course, there would be no floor or bottom to the box, and it should be made so that it would clear the ground by any predetermined amount. It might be safer if the house had no back.

Another suggestion offered more seriously where record-breaking without pace-making is the object, is that a day should be chosen when the barometer is very low, for a fall of an inch, if it reduced the air resistance by one-thirtieth, might mean a gain of a second in a minute, or a minute in an hour, *i.e.* if the corresponding diminution of oxygen in the rider's lungs did not compensate for the reduced resistance.

The chapter on gearing is one that cycle inventors would do well to study. It is interesting here to find the Simpson lever chain under the heading "Perpetual Motion." Mr. Sharp very clearly and forcibly points out the fallacy that renders auxiliary hand-power mechanism a practical failure.

Part iii. opens with two chapters upon the frame, which will probably be found to designers the most useful in the whole book. Graphic methods, explained in the first part, are employed to show how the stresses in a link-work frame can be calculated. It is clearly important that the design should be such in a cycle frame, that the members of the frame may be mostly in tension or compression, as they would be if they were pivoted and not brazed together. The difficulty of dealing with the actual case in practice in which they are brazed, and stresses other than tension and compression are certainly met with, is only referred to, but, perhaps wisely, the anxious engineer is not shown how to reduce these to figures.

It is a question whether too much stress has not been laid upon the necessity of straight members in a cycle frame, for in order to meet the racking and other stresses which must be met with in practice, a gauge of tube is necessarily employed, which, considering the frame as a mere girder carrying a dead weight, is quite absurdly strong, so that a moderate bending moment, due to the design, need not be feared when some distinct gain is effected in consequence.

This is more especially the case in the dropped frame which, unfortunately for themselves, ladies in this country think they prefer. Great abuse is often heaped upon the makers of machines with curved frames. Now, provided that the top and bottom members are kept apart, and the more so the better, and are effectively stayed at a few points, the bending stresses introduced by the curvature are quite moderate, and space is obtained where it is required, so that mounting and dismounting is more easy A further point is the extra steepness of the frame in front, which allows the skirt to hang more easily.

Mr. Sharp accepts the situation with regard to ladies' machines as he finds it at the present day in this country. Again, perhaps, he is wise. He assumes a drop frame to be a necessity. Now, if any person will depend upon reasoning alone, and pay no attention to the vagaries of fashion, he will see first, as is evident from Mr. Sharp's diagram, that the stresses in a so-called lady's "Safety" are greater than in one of proper design, so that in order to make it strong and stiff enough the machine has to be heavier than any that a man would ride, and is even then without that wonderful rigidity of the diamond frame.

Add to this the fact that the fair sex have not the strength or any of that recuperative power necessary in case of emergency that man possesses, and that they suffer many fold from the ever-disturbing wind resistance in consequence of the garments which fashion imposes upon them, and that because of these same garments they are in sorry plight in case of a moderate accident; with all this in the mind of a mere reasoning person, there is no wonder that he thinks of something else, the degree question at Cambridge for instance. Had the suburban ladies been given another year or so before the desire to ride a bicycle extended so far in the direction which is known from a mere social point of view as upward, it is possible that the change of attire would have spread gradually, and that now, or perhaps in a year or two, suitable costume would have been adopted as readily as the cycle jargon and slang so often met with. Ladies start with every natural disadvantage, and then they proceed to magnify them in a more effective way than their conscious ingenuity could devise.

The chapter on wheels is one which will be read with interest by riders especially. Here will be found a description of the author's tangent wheel, in which the spokes are not fastened to the hub at all! It is almost impossible to believe at first that spokes held in pairs to the hub by merely having their common centre portion wound a fraction of a turn round the hub will hold sufficiently tight to withstand all the twist that a strong rider can exert upon them. But the theory is convincing, and especially when steep-angled grooves are employed in which to lay the wire, no doubt can remain that this is the case.

Ball-bearings form the next subject, and these are treated far more thoroughly and scientifically than is usual. The actual want of absolute perfection in the ordinary bearing is pointed out, and a number of suggestions made for bearings in which the balls approach as near as possible to the state of pure rolling. The ordinary ball-bearing answers so well, in spite of the spinning and rubbing friction which accompanies the rolling, that it is hardly likely that the more elaborate bearings, in which these defects are reduced or abolished, will take their place. At the same time, a discussion of them is of educational value to designers.

Chains and chain-gearing are dealt with very thoroughly and completely. There is one omission, however, which must be noticed, and that is all reference to the results of Hans Renold, of Manchester, who found that a small difference of pitch is desirable in the driving and driven wheel. The writer of this notice picked up one of Renold's pamphlets at a cycle show some years ago, and was much struck with the arguments there used. It may be that this is all common knowledge, or that it is mistaken; but either way, one would like to have had Mr. Sharp's views upon the subject.

Mr. Sharp explains the correct method to setting out chain wheels for long-link and for block chains; he is not afraid of criticising one of the chief companies.

"In Humber pattern chain-wheels the teeth are often quite straight (Fig. 451). This tooth form is radically wrong."

On page 417, Mr. Sharp points out a defect in a usual pattern of chain which the practical man would hardly expect. Here the plates of the chain are cut away on the side next the chain-wheel, so that the line joining the rivets is not in the middle of the portion that is left. If the plates were cut away on the other side as well, so as to leave less metal, they would be stronger still. In the next page there is a suggestion which seems valuable, namely, to make the side plates of metal which has been stretched beyond its elastic limit, and which therefore has an increased rigidity. As these links can never be subjected to compression, the objection to this procedure, which is met with in other cases—as, for instance, in Southard's twisted cranks—does not apply.

The bicycle chain is a more marvellous piece of mechanism than is generally supposed. The pins have to bear a force which is far greater than is prudent in ordinary structures, while the bearing surface of the blocks on the rivets have in use occasionally to bear more than twice the amount given by Prof. Unwin as the maximum value for bearings on which the load is intermittent and the speed slow.

The discussion on the variation of relative speed in the driving and driven wheel is curious rather than important.

One result of the rules given by Mr. Sharp for shaping the teeth of sprocket wheels is that even in elliptical wheels the teeth will have the same form as in circular wheels of any size, so that the same cutters can be employed for all wheels if adapted to the tooth face, and not made simply to plough out the space between two teeth at one cut.

The practical reader would like to know whether the tooth forms recommended work well in practice, for there is undoubtedly much prejudice in favour of the patterns of our standard makers, whether condemned by Mr. Sharp or not.

Toothed-gear wheels are treated at length. The theory is, of course, common knowledge, but it is very well put, and the results of a paper on circular-wheel teeth, published by the author in the *Proceedings* of the Institution of Civil Engineers, are given also. Toothed-wheel gears follow. The mechanical reader who is not already acquainted with these, will be surprised at the ingenuity and perfection which are embodied in this class of work.

There is much remaining unnoticed, but the length to which this review has reached is such that many interesting points cannot be even mentioned.

"Bicycles and Tricycles," by Sharp, has taken its place as the one standard book which ought to be found wherever cyclists do congregate, and which no one designing or inventing any detail connected with a bicycle should fail to possess.

C. V. BOYS.

THE GEOLOGY OF THE BRITISH ISLES.

Geological Map of the British Isles. Originally compiled by Sir Archibald Geikie, LL.D. Revised and extended by Alexander Johnstone, F.G.S. (Edinburgh and London: W. and A. K. Johnston, 1896.)

Mineralogical Geology: a Synopsis for the Use of Students. To accompany W. and A. K. Johnston's Geological Map of the British Isles. By Alexander Johnstone, F.G.S. (Same publishers as above, 1897.)

THE first of these works is by a long way the best and most convenient geological map of the British Isles, both for lecturers and students; and this new and greatly